The CGC and the Cronin effect

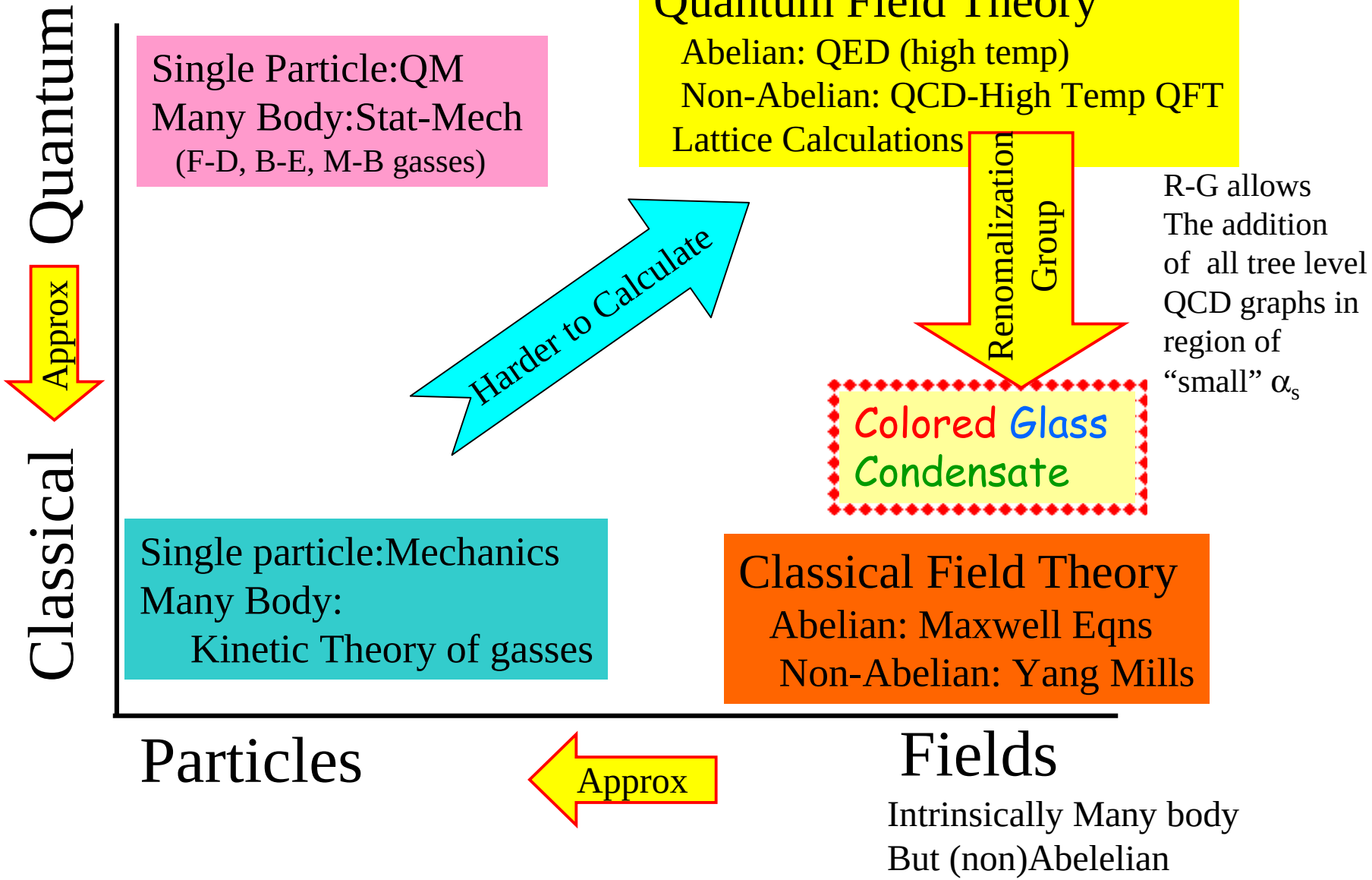
This is my attempt to understand the reconciliation between the Jamal-Marian CGC “Cronin” calculation and the Kharzeev et al prediction for dA. It is not meant to be a tutorial on the CGC but simply to clarify a few points. Hope its helpful

Richard Seto

Apr 3, 2003

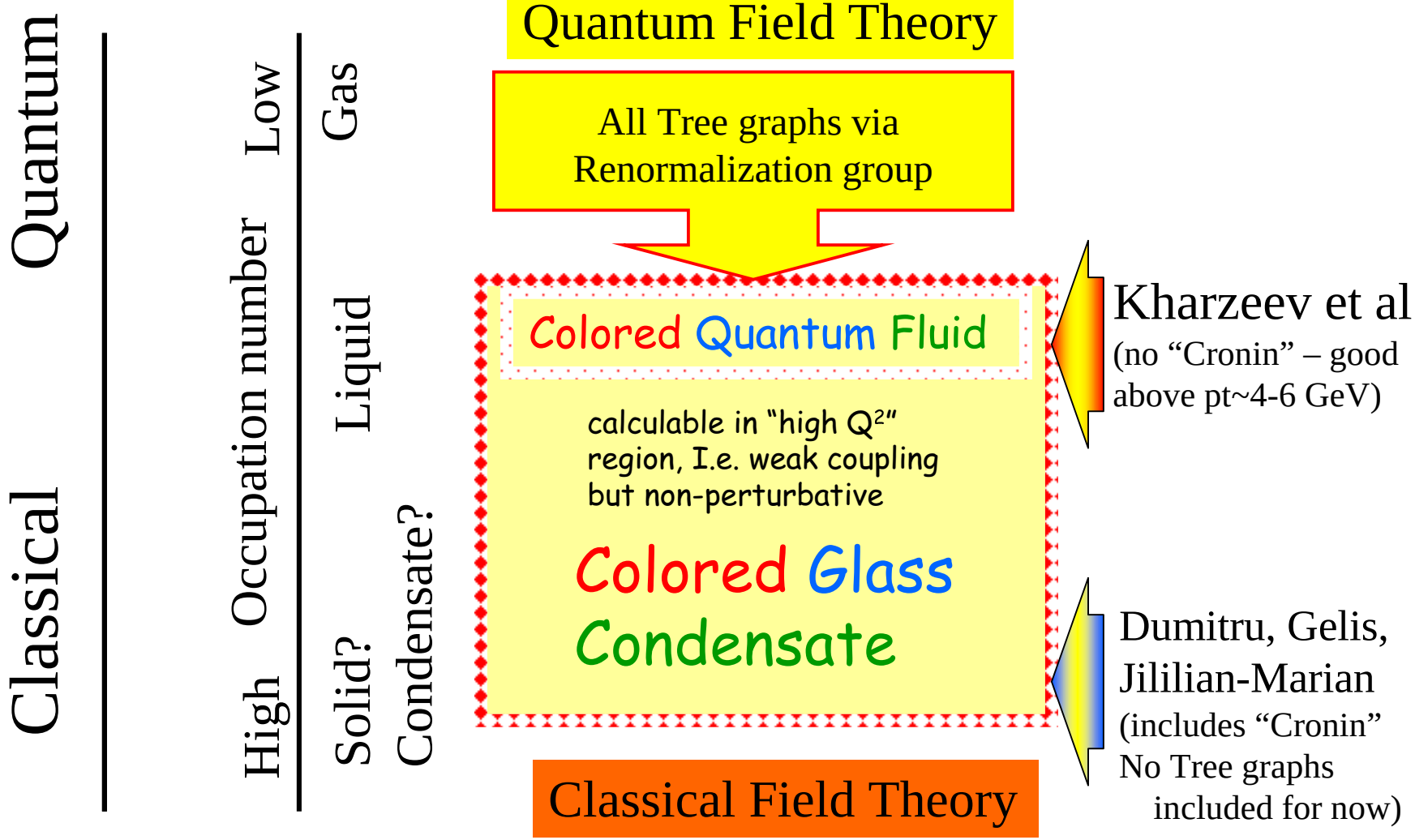
Updated Apr 5 – not much changed

Putting the CGC into context

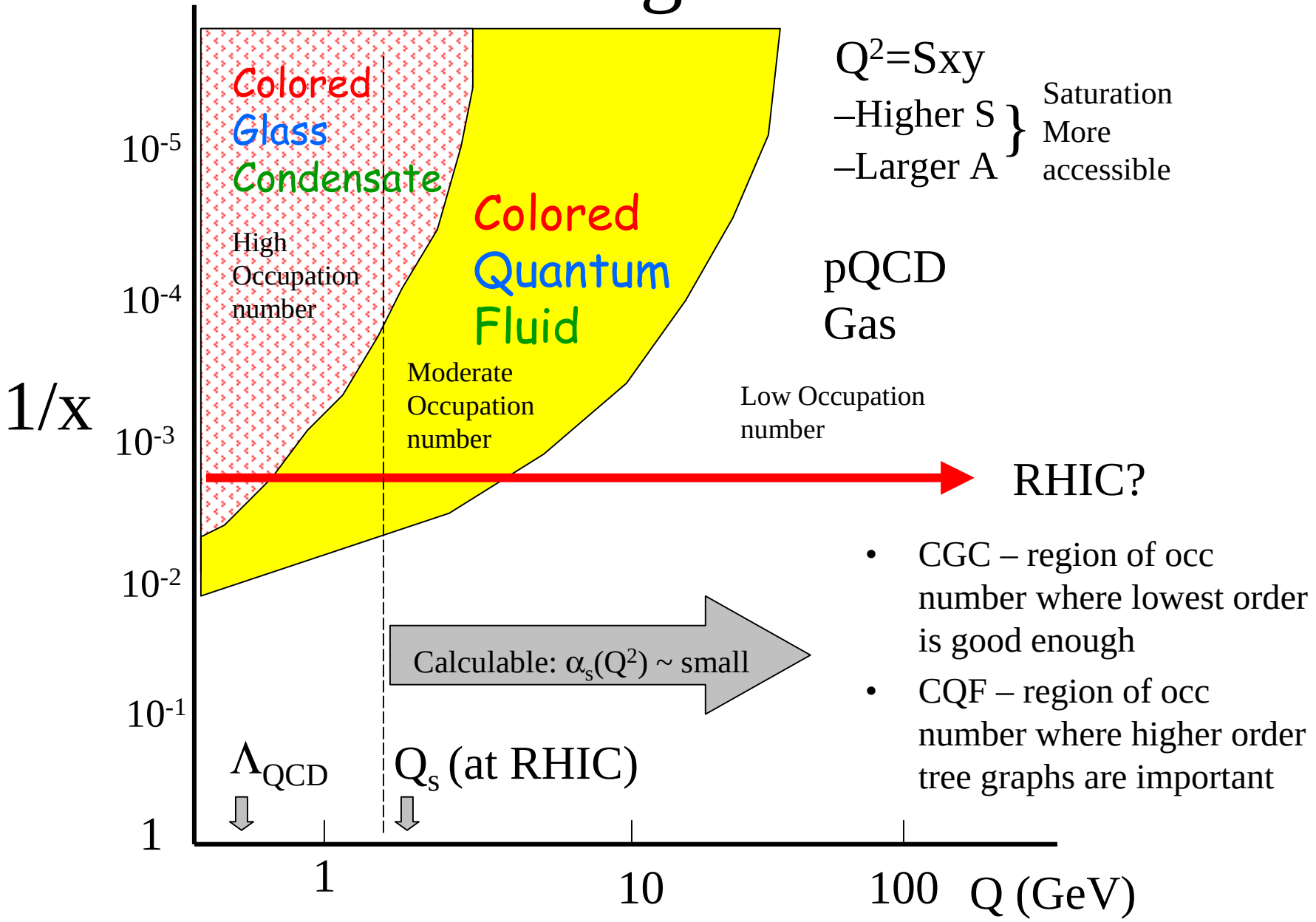


Relevant regions of calculability for QCD

The CGC has split into 2 regions (the CGC and the CQF)



Regions



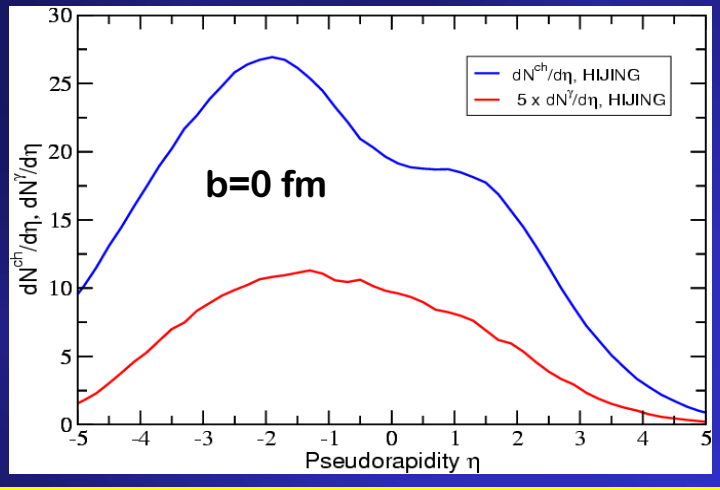
- CGC – region of occ number where lowest order is good enough
- CQF – region of occ number where higher order tree graphs are important

Notes on the CGC

- Dima is only willing to predict total charged spectrum at high pt and not pions
  - I don't completely understand why but you can ask
    - (it has something to do with the unkown fragmentation functions of very virtual quarks, different than the almost on-shell nature of fragmenting quarks in e^+e^-)
    - They ignore final state interactions (jet suppression, flow, coalecence…) If these are present then they "hide" the CGC
  - Hence we cannot make a direct comparison with the π^0 which I believe is the cleanest handle we have on jets
  - Our charged suppression is ~ 0.5 so $R_{d+Au}=\sqrt{R_{Au+Au}}=\sqrt{0.5}=0.7$
- My guess as to the relationship between "shadowing" and the CGC
  - The CGC is really a word describing a region (high occ number) which can be calculated from "first principles" using QCD. It is less a model than an approximation. Hence it can describe shadowing from "first principles"
- Its not clear that the CGC theorists agree with each other on all this

Predictions

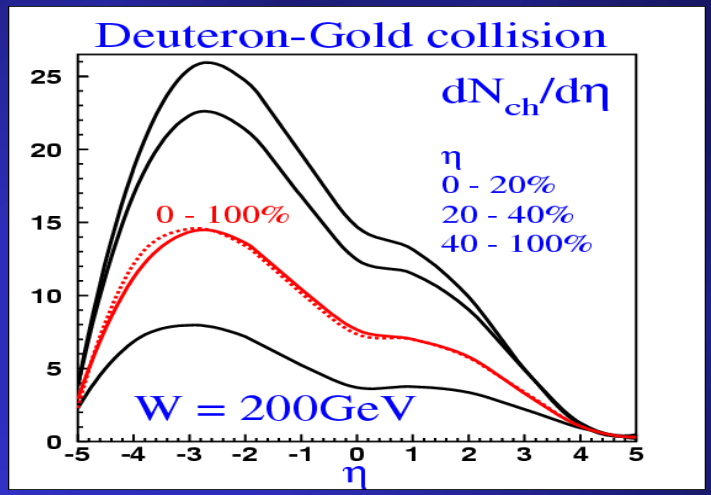
HIJING 1.37 simulation;
X.N.Wang and M.Gyulassy, Phys.Rev.Lett. 68, (1992)



$dN_{ch}/d\eta$

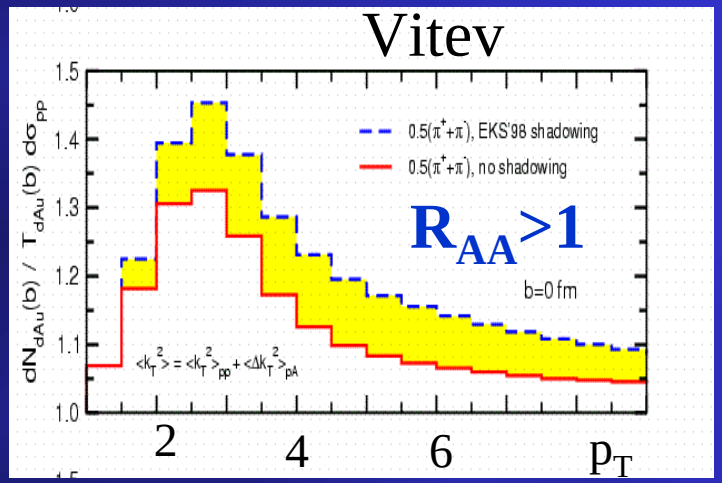
Not much Difference Between "standard" Models and CGC

D.Kharzeev, E.Levin and M.Nardi, hep-ph/0212316



"CGC"

More standard "jet suppression" models

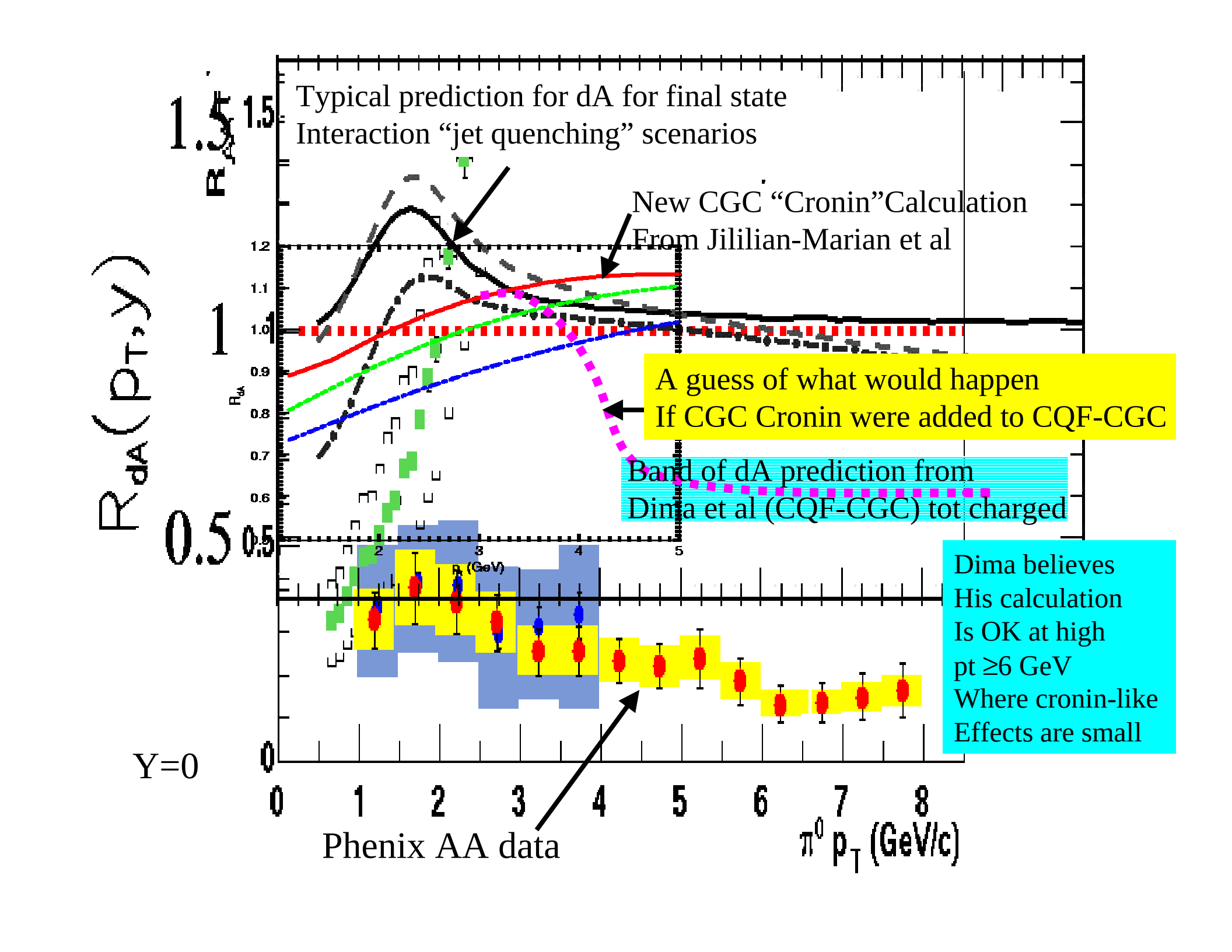


R_{AA}

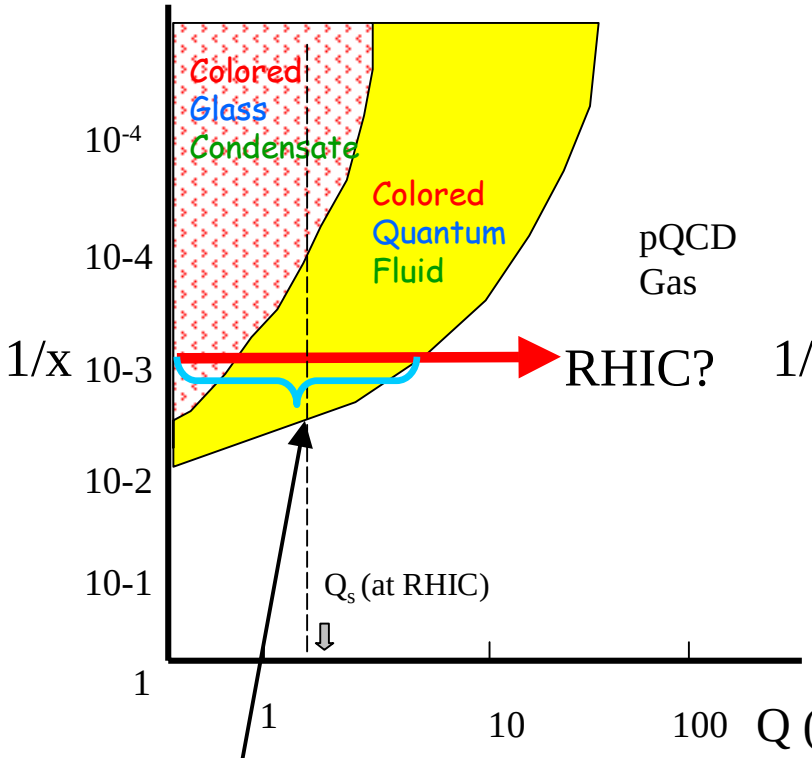
$R_{d+Au}=\sqrt{R_{Au+Au}}$

$\sqrt{0.5}=0.7<1$

See next page

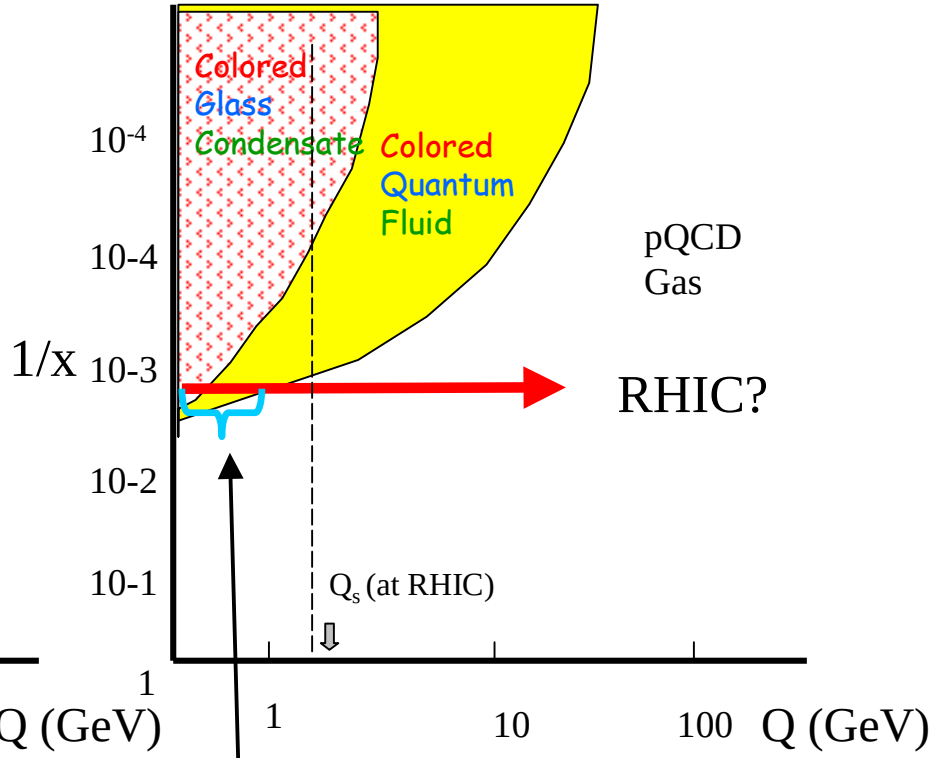

Typical prediction for dA for final state
Interaction "jet quenching" scenarios
New CGC "Cronin"Calculation
From Jililian-Marian et al
A guess of what would happen
If CGC Cronin were added to CQF-CGC
Band of dA prediction from
Dima et al (CQF-CGC) tot charged
Dima believes
His calculation
Is OK at high
pt ≥6 GeV
Where cronin-like
Effects are small
Y=0
Phenix AA data
$R_{dA}(p_T, y)$
π^0 p_T (GeV/c)

A couple possibilities for the CGC



- Exp result:
  - Multiplicity: is as CGC (or other models) predicts
  - High pt dA: suppressed

➔ RHIC in regime in which CGC affects high pt



- Exp result:
  - Multiplicity: is as CGC (or other models) predicts
  - High pt dA: NOT suppressed

➔ RHIC in regime in which CGC affects only low pt (mult) but not high pt

Summary (mostly from MG)

- Two extreme opposite interpretations of RHIC AA data exists

  Evidence for opaque 100 x nuclear density matter
  Evidence for deep gluon shadowing (saturation)

  Ambiguity due to competition between initial nuclear wavefunction, Shadowing, initial state (Cronin) interactions, and final state int.
  - as pointed out in 1992 p+A (or d+A) needed to isolate *Initial State* effects : shadowing and Cronin

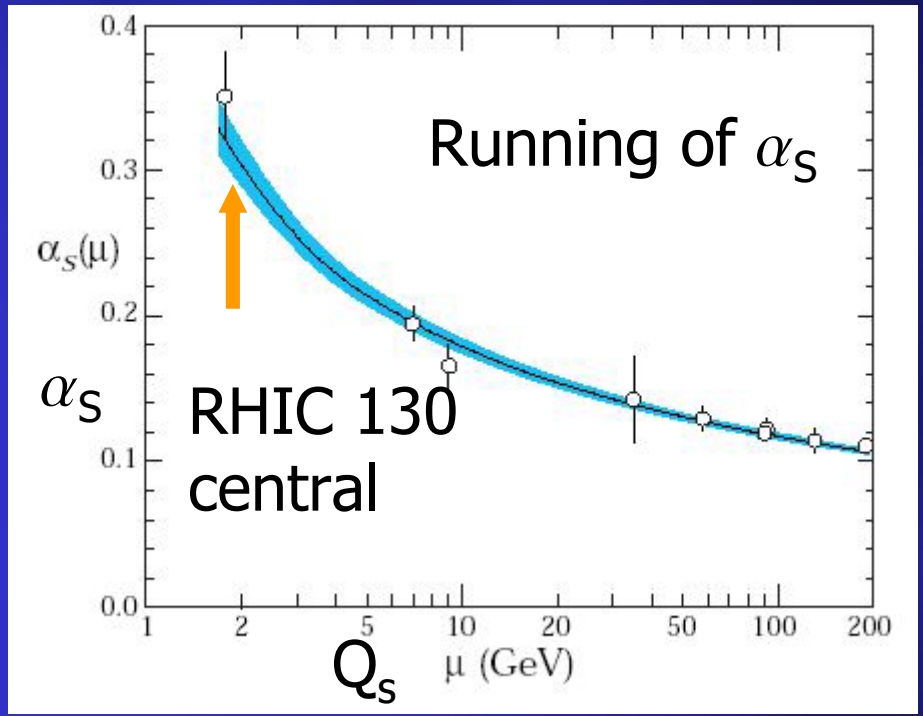
    IF RHIC finds R(5 GeV) ~ 1.1-1.3 in d+Au , then
    interpretation (1) QGP matter was produced in AA
    And RHIC AA Has chance to map out QCD EOS
    (rks) CGC may still give us the initial state

    IF RHIC finds R(5 GeV)< 0.7 in d+Au , then
    interpretation (2) and AA= shattered color glass
    No QGP matter => go to eRHIC to map xGA.

    IF RHIC finds 0.7< R(5 GeV) < 1 Back to the drawing board ???
    (rks) probably combination of both

QCD- RG and the CGC

- Renomalization Group Theory gives us a way of summing ALL graphs of a certain kind (in particular "tree graphs")
  - For the CGC these are to first order in $\alpha_S \ln(1/x) \ln Q^2$
  - For PQCD this is all graphs usually to first order in $\ln Q^2$



At RHIC, Q_S~1-2 GeV
$\alpha_S(Q_S)$~0.3 –0.4